

# News Briefs

---

## General Developments

*Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards and Technology, Building 820, Room 126, Gaithersburg, MD 20899-0001; telephone: 301/975-3572.*

---

### ELECTRONIC MARKET OPEN FOR RECYCLED MATERIALS

The saying, "One man's garbage is another man's gold," is now truer than ever with the recent launching of the Chicago Board of Trade Recyclables Exchange, a centralized electronic marketplace for buying and selling recyclable materials. With funding from NIST's Manufacturing Extension Partnership (MEP) and others, the Clean Washington Center (a division of the Washington State Department of Community, Trade and Economic Development) played a key role in helping to design the system, which will enable participants to use an on-line electronic bulletin board to buy or sell recyclable materials. The center also developed both the testing protocols and the standardized quality definitions for recyclable materials that will be used in this worldwide market. The exchange will help create a more stable marketplace for these materials, provide more timely and accurate price information, and give buyers a better assurance of quality. Initial materials to be traded on the exchange include various grades of recovered glass, plastic and paper. The center has joined with NIST's MEP to help increase the acceptance and use of recycled materials by small and medium-sized manufacturers. For further information regarding the Clean Washington Center and the recyclables exchange, contact Elizabeth Burger at (206) 389-2530.

### U.S., CANADA TEAM ON VENTILATION STRATEGIES SOFTWARE

American and Canadian researchers have joined forces to develop a computer program that will be used to

design buildings for good indoor air quality. The 3 year project between NIST and the Institute for Research in Construction of the National Research Council Canada will create a Microsoft Windows™ based computer program to predict indoor contaminant levels before a building is constructed and occupied. The software program also will enable users to analyze indoor air quality in existing buildings. With the program, designers may explore trade-offs between material selection and ventilation rates to achieve acceptable indoor air quality without compromising energy efficiency. Manufacturers of building materials will be able to evaluate how their products impact indoor air quality and provide the basis for indoor air-quality-related claims for marketing purposes. Other possible users include building owners and managers, who could assess the existing conditions in a building and explore options for improving its indoor environment. For more information, contact Andrew Persily, A313 Building Research Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-6418, e-mail: andyp@enh.nist.gov, or Jianshun Zhang at NRC, (613) 993-9538.

### LESS WAFER "REAL ESTATE" NEEDED TO MEASURE MMICs

Monolithic microwave integrated circuit, or MMIC, microelectronic chips are becoming more commercially important for applications such as wireless communications and smart transportation systems. However, they pose a challenge for those wanting to accurately characterize their microwave performance. A new method for calibrating measurements on MMICs has been developed by two NIST researchers that greatly reduces the amount of wafer space needed, yet has no significant loss in accuracy, when compared to previous measurement methods. The system is applicable to a wide variety of MMICs fabricated with both co-planar waveguide and microstrip transmission lines. However, the method cannot be used to characterize a MMIC's entire microwave performance because it only gives

accurate results at high frequencies and not low. For technical details, contact Robert Judish, Div. 813.06, NIST, Boulder, CO 80303-3328, (303) 497-3380, e-mail: judish@boulder.nist.gov.

## **NEW GUIDE HIGHLIGHTS EU STANDARDS SETTING**

NIST Special Publication 891, Standards Setting in the European Union—Standards Organizations and Officials in EU Standards Activities, a joint publication of NIST and the Commercial Service at the U.S. Mission to the European Union, provides information on the harmonization of standards in the EU for U.S. manufacturers, exporters, government, and private-sector officials. Information was obtained from interviews and documents provided by the EU Commission and major, key standards-developing organizations in the EU: the European Committee on Standardization (or CEN), the European Committee for Electrotechnical Standardization (or CENELEC) and the European Telecommunications Standards Institute (or ETSI). These are the organizations that are competent to develop or adopt the harmonized standards needed to achieve conformity to the EU “New Approach” and “Global Approach Directives.” Included are lists of EU New Approach Directives, NIST standards-related publications, sources for standards in the United States and Europe, and contact points for information. SP 891 is available for \$5 prepaid from the U.S. Government Printing Office, Washington, DC 20402, (202) 512-1800. Order by stock no. 003-003-03369-3.

## **“MAIL LIST” NOW ONLINE FOR MICROWAVE METROLOGY**

If you’re hooked up to the Internet and have questions regarding the measurement of microwave quantities, then NIST wants to hear from you. NIST has set up an electronic mailing list as an open forum for discussion on technical issues and problems regarding microwave metrology. NIST hopes the link will serve industry as a useful source of contacts and information, giving benchtop technicians and engineers a place to ask questions and share their expertise. To subscribe to the service, simply send e-mail to: major-domo@central.bldrdoc.gov. The body of the message should read: subscribe mwave-meas (your e-mail address). To cancel the service, substitute the command “unsubscribe” in place of subscribe. There is no cost for subscribing. To get help or find out more about the list server, send e-mail to major-domo@central.bldrdoc.gov with the word “help” in the body of the message. Once subscribed, one simply

sends mail to mwave-meas@central.bldrdoc.gov to post a message to all of the members on the list. If you prefer to talk by voice to someone about this, call J. Wayde Allen at (303) 497-5871.

## **NEW VIDEO PROFILES NIST’S LINKS WITH INDUSTRY**

A new video, “Building and Fire Research Laboratory—Your Partner in Building,” reviews NIST programs critical to industry such as energy efficiency techniques, fire loss reduction procedures, and construction automation advances. The 17-minute video describes NIST’s ongoing partnership with the private sector as it examines NIST’s people and programs in structural and materials engineering, mechanical and environmental systems, fire safety and engineering, fire science, and applied economics. VHS copies of the program are available for \$22.50 (including shipping and handling) from Video Transfer Inc., 5709-B Arundel Ave., Rockville, MD 20852, (301) 881-0270. For overseas customers, VHS copies in PAL and SECAM formats also are available at \$22.50 each. For more information on BFRL programs, contact Noel Raufaste, B250 Building Research Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-5905, e-mail: raufaste@mifc.nist.gov.

## **PAPERS WANTED FOR MICROELECTRONICS WORKSHOP**

Electronic engineers, materials scientists, designers and others engaged in the development of microelectronic products are invited to submit papers for the Sixth International Workshop on Moisture in Microelectronics, Oct. 15-17, 1996. To be held at NIST’s Gaithersburg, MD, headquarters, the workshop is cosponsored by the agency and the U.S. Air Force Rome (N.Y.) Laboratory. The goal is to help U.S. industry respond to the challenges and concerns associated with moisture in the manufacture and use of semiconductor packages and electronic interconnects. Advancements in the current state of moisture measurement, modeling, and their impact on the performance and reliability of materials, devices and assemblies will be documented at the workshop. Abstracts of 100-150 words must be submitted by March 1, 1996. For information, contact Michael A. Schen, B320 Polymer Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-6741, fax: (301) 869-2339, e-mail: michael.schen@nist.gov, or Benjamin A. Moore, Rome Laboratory, 525 Brook Rd., Rome, NY 13441-4504, (315) 330-3450, fax: (315) 330-2247 or 2153, e-mail: mooreb@rl.af.mil.

## FANFARE ON NEW YEAR'S EVE ON HOLD FOR A SECOND!

The keepers of the nation's primary standard of time and frequency, the NIST-7 atomic clock at NIST's Boulder (CO) laboratories, added a leap second (as did the operators of all other standard clocks around the world) on Dec. 31. This was the 20th such adjustment to the world's time scale, as decreed by the International Bureau of Weights and Measures in Paris. Leap seconds are needed to keep our clocks (the best of which are now so accurate that they lose or gain less than a millionth of a second per year) in step with the spinning Earth, which varies several thousandths of a second per day. Since we cannot speed up the Earth, we have to slow down the clocks every 1 to 2 years to keep them "in sync." This is done by stopping them for exactly 1 s so that the Earth can catch up. This year's leap second was inserted at 23:59:60 Coordinated Universal Time (7 p.m. EST) on Dec. 31, 1995. Therefore, the official last minute of 1995 was actually 61 s long.

## PARTNERS SCORE SUCCESS WITH ULTRASONIC SENSOR

A private company has adapted a NIST-developed ultrasonic system to inspect airbag inflators for welder verification and process control. The company is a leading supplier of airbag inflators to the automotive industry. Under a cooperative research and development agreement, NIST worked with the company's engineers to develop, test, and install a prototype nondestructive testing system for verifying that there are no anomalies associated with the weld joint process of the mass-produced inflators. A unique feature of this inspection system was the use of electromagnetic acoustic transducers, or EMATs, which can perform the necessary ultrasonic tests at high speed without contaminating the part or the environment with couplant fluids. Off-line trials involved examining up to 100 000 inflators and were so successful that the company contracted a second company to build three commercial units. These units are now installed on the production lines and provide process control information on the welding operations.

## NIST "OPEN" CONTROLLER GETS TEST DRIVE

NIST has developed a prototype, open-architecture controller designed to validate standard interfaces for machine tools. The ultimate aim of the collaborative effort is to make upgrading and customizing of manufacturing equipment as uncomplicated as installing new hardware or software on personal computers. In the first of several factory-floor trials, the NIST enhanced

machine controller, or EMC, is undergoing an extended test drive at a major automobile manufacturer. After a round of preliminary tests and comparisons by the automobile company's engineers, machinists now are getting their chance to judge the EMC's performance on a four-axis milling machine. During the plant's two-shift operation, the machine is used to mill, drill, tap, and cut parts for auto transmissions. The trial will provide feedback on how well the experimental controller withstands real factory-floor use. Tests at the automobile manufacturer and other production sites will demonstrate whether the NIST approach can simplify programming and integration tasks. Today, most controllers are designed with closed, or proprietary, architectures. Software must be written to specifications unique to a particular controller. The goal of the EMC effort and complementary activities under way elsewhere is to develop and validate programming interfaces for a variety of machine tool applications, enabling so-called "plug and play" compatibility and interoperability. To further technical efforts, NIST is organizing an EMC Consortium. Partners will specify, develop, and test programming interfaces for high-priority applications, intending to advance these interfaces as national and international standards for open architecture controllers. For more information, contact Fred Proctor, B124 Metrology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3425, e-mail: fproctor@nist.gov.

## REPORT LINKS TECHNOLOGY AND ECONOMIC GROWTH

Do R&D tax credits work better than direct government funding to stimulate corporate research? A new report, *Technology and Economic Growth: Implications for Federal Policy*, answers that question and many others that have confused discussions about the economic impacts of technology and the effectiveness of government programs. Written by a NIST economist, the 76-page document summarizes and interprets several decades of economic research on the economic impacts of technology and presents rationales for government roles in support of technology investment by the private sector. The report also provides an analysis of some of the more important foreign government policy initiatives in this area. The report's main conclusion is that while "industry is the prime mover of economic growth, a technology-based economy requires a range of government infrastructure roles that are more complex than the ones that leveraged the industrial revolution a century ago." Warning that action is being slowed by persistent confusion about technology's impact in a modern economy and protracted debate over the proper roles of industry and government, the report seeks to clarify the facts and

framework for decisions on federal policies. Available while supplies last by sending a self-addressed mailing label to: Greg Tassey, A1000 Administration Building, NIST, Gaithersburg, MD 20899-0001.

### **HIGH-TEMP SUPERCONDUCTING CIRCUIT FABRICATED**

Scientists at NIST have built and demonstrated one of the most complex high-temperature superconducting circuits ever designed. This device, a high-frequency oscillator, eventually could be used in receivers operating in the millimeter-wave to far-infrared (terahertz frequency) region. Tunable frequency sources have not been readily available in this region but are needed for applications such as observation of atmospheric gases, astronomy and advanced communication systems. The oscillator is based on a novel circuit concept developed by a NIST guest scientist from the German research institute, KFA-Juelich. It relies on the well-known property of Josephson junctions to convert voltage to frequency at cryogenic temperatures. However, these devices have been unreliable when fabricated from so-called high-temperature superconductors. The solution? Use microwave resonators to obtain coherent interactions among the five Josephson junctions. Power was detected from 60 GHz to 250 GHz with a maximum power of 4 nW at 160 GHz. The next step is to construct an array with many more junctions (up to 100), which will produce a microwatt of power, enough to be useful. To obtain paper no. 25-95 describing this development, contact Sarabeth Harris, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, e-mail: sarabeth@micf.nist.gov. For technical information, contact Ron Ono at (303) 497-3762.

### **MASS METROLOGY COMPARISONS TO ENHANCE TRADE**

Measurement scientists from five regional organizations of the Americas recently met at NIST to develop procedures for the comparisons of mass measurement standards between the national laboratories in the 34-member Organization of American States. The goal is to ensure that when producers and manufacturers measure a kilogram of a commodity in one country, it will be identical in weight in another Western Hemisphere nation. The effort is being sponsored by NIST, OAS and the U.S. Mission to OAS. The comparisons of mass standards is one of several intercomparisons that will take place to promote traceability of standards between countries in various regions and among regions of the Interamerican Metrology System (known by the abbreviation of its Spanish name, SIM). After SIM regional workshops, NIST will collect data and invite officials to return and analyze the data and

establish linkages. Following this second meeting, regional representatives will hold additional workshops. The mass calibration services offered by OAS members will have a known relationship to each other and to the International Bureau of Weights and Measures in Sèvres, France. Plans call for intercomparisons of electrical and pressure standards, and Mexico will lead an effort on the intercomparisons of temperature standards.

### **“CRACK” ASSESSMENT OF BRIDGES DETAILED**

A recent paper by researchers at NIST uses fracture mechanics to assess cracked bridge members such as beams. For example, if crack length and stresses are known, the crack driving force (stress intensity factor) can be calculated—in items such as splices and hot-rolled beams—as a function of crack length. The crack driving force eventually becomes negative for these cases, indicating no further crack propagation, the report says. However, a deeply cracked girder will become compliant and “shed” load to uncracked neighboring members. This phenomenon was calculated for a three-girder bridge. On long, narrow bridges, the girder has to be about 80 % cracked before shedding occurs, the authors found. They also used ultrasound to study fatigue loading, another significant failure mechanism. Measurement of velocity changes give changes in stress. Another use of ultrasound detailed is determining the crack driving force and characterizing stresses in bridge pin and hanger assemblies. For a copy of the paper, “Quantitative Bridge Safety Assessment Utilizing Fracture Mechanics and Ultrasonic Stress Measurements,” contact Sarabeth Harris, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, e-mail: sarabeth@micf.nist.gov.

### **NIST EM AND OPTOELECTRONIC PUBS INDEXED**

Persons interested in NIST's electromagnetic and optoelectronic research will want copies of two new bibliographies of technical publications. The period covered extends from the late 1960s until June 1995. The electromagnetic research is in the areas of cryoelectronic metrology and superconductor and magnetic measurements. The optoelectronic research is in the areas of sources and detectors, fiber and integrated optics, optical components, and optoelectronic manufacturing. A limited number of copies of the bibliographies are available from the editors. To obtain *Metrology for Electromagnetic Technology: A Bibliography of NIST Publications* (NISTIR 5040) contact Ann Bradford at (303) 497-3678. To obtain *A Bibliography of the NIST Optoelectronics Division* (NISTIR 5041), contact Annie Smith at (303) 497-5342.

**OIML AND APLMF MEETINGS IN BEIJING**

The People's Republic of China hosted the 30th meeting of the International Committee of Legal Metrology (CIML) of the International Organization of Legal Metrology (OIML) and a meeting of the Asia Pacific Legal Metrology Forum (APLMF) in Beijing from Oct. 22-28, 1995. Representatives from 42 of the 54 OIML member nations and representatives of 18 of the APLMF member nations attended.

China's Vice-Premier opened the CIML meeting, stressing the significance and importance of international cooperation in harmonizing legal metrology for eliminating trade barriers and for promoting economic construction, scientific and technological progress, and social development. The CIML approved four OIML recommendations, and ad hoc task group was appointed to meet with a comparable group of the International Committee of Weights and Measures (CIPM) to discuss a French government proposal regarding the merger of the Treaty for OIML and the Meter Convention.

At the meeting of the APLMF, the Secretariat, Australia, presented the results of surveys of member nations on "Legislation," "Prepackaged Products," and "Training" with the aim of identifying needs for development and harmonization.

CIML will meet next in November 1996 in Vancouver, British Columbia, Canada, in conjunction with the 10th International Conference of Legal Metrology. APLMF is scheduled to meet in conjunction with these OIML meetings.

**INTERAGENCY COMMITTEE ON STANDARDS POLICY MEETING**

The Interagency Committee on Standards Policy (ICSP) met on Oct. 19, 1995 to continue its ongoing dialogue to accomplish the objectives of OMB Circular A-119, "Federal Participation in the Development and use of Voluntary Standards." Senior standards executives and other representatives from 20 Federal agencies attended the meeting. A variety of Federal standards-related policy issues were addressed, including laboratory accreditation, the potential implications of new international environmental standards, interagency coordination of standards-related information directories, ISO 9000, and strategic standardization activities. Under the OMB Circular, the Department of Commerce, through NIST, provides the chair and executive secretariat for the ICSP. In addition to implementation of the circular, the ICSP works toward greater cooperation among Federal agencies and between them and the private sector, and for a more unified governmental position in international standards activities.

**INFANT FORMULA WORKSHOP**

In response to the Nutrition Labeling Act, NIST hosted a workshop with seven laboratories from the industrial sector, and two Federal agencies. The focus of the workshop was the evaluation of the analytical data generated in a collaborative study to explore certification of concentrations of mainly proximate and organic constituents in Standard Reference Material (SRM) 1846, Infant Formula. The SRM is needed by industry to achieve compliance to measurement requirements related to the implementation of the Nutrition Labeling Education Act and the Infant Formula Act. The Infant Formula Council, Atlanta, Ga., coordinated part of these efforts, with considerable initial analytical input from the National Food Processors Association, Washington, DC.

The aim of the workshop was to discuss quality assurance procedures followed by the participating laboratories during the analysis of the SRM. The information obtained will be used to evaluate the analytical results and appropriate statistical data treatment for the certification process. The new SRM 1846 Infant Formula will be certified for caloric energy, protein, fat, and carbohydrate content as well as the concentration of a number of vitamins and minerals.

**ENERGY-RELATED INVENTIONS PROGRAM RECOMMENDATIONS**

The NIST Office of Technology Innovation recommended four innovative technologies for commercialization to its Department of Energy partner under the Energy-Related Inventions Program during October 1995. They included:

- Load Management Device and Method of Use—a unique remote control system for use by utility companies to disconnect electrical appliances during times of peak power demands.
- Laser Television—an innovative semiconductor diode-based laser system using red, green and blue diode lasers as the light sources to provide a high-definition television (HDTV) projection unit.
- Exterior Central Air Filtering System "a patented flexible filter wrapped around the air intake of the outdoor condensing units of residential and light commercial air conditioning systems.
- Increased Productivity and Safety In Mines Through Real-Time Wireless Through-the-Earth Telecommunications—a transmitting and receiving system using very low frequency radio waves for communicating on a real-time basis through the ground between the surface and the mine underground, for monitoring equipment in mines.

## NIST TECHNIQUE ADOPTED IN STANDARD FOR TESTING OF EQUIPMENT FOR ELECTRIC POWER GRID

A convolution technique developed at NIST is now included as one of the tests for verifying the accuracies of reference high-voltage dividers in the latest version of IEEE Standard 4–1995, Standard Techniques for High-Voltage Testing. This standard, issued in October, 1995 governs the testing of the high-voltage equipment on which the reliable transmission and distribution of electricity depends. Equipment for the power grid must be able to withstand the effects of lightning, simulated in testing by specified high-voltage impulsive waveforms. Since direct measurement of the waveform at high voltage is difficult, a reference voltage divider is used to provide a low-voltage waveform for measurement. The problem is to determine how well the waveform at high voltage corresponds to that at low voltage.

The NIST technique uses a numerical convolution to calculate the output of the high-voltage divider by using the measured response of a divider to a low-voltage step together with an analytical waveform of the type to be measured. These waveforms are known as standard lightning impulses (SLIs); the standard specifies that the voltage rises to its peak value in about a microsecond and falls to half its peak level in about 50 µm. The standard also specifies an SLI variant known as a chopped lightning impulse (CLI). A divider used to perform measurements of the SLIs and CLIs in equipment testing must scale the high-voltage impulse to measurable voltage levels in such a way that the difference between the characteristic time parameters of the high-voltage input and of the measured output waveforms does not exceed prescribed limits. The convolution technique provides an easy way of making the comparison; there is no need for a second divider measurement system to provide a reference. The check can be done quickly with a digital recorder to measure the response waveform and a personal computer to perform the calculations. Further, the test operator can see the distortion introduced by the divider by comparing the input SLI waveform and the divider output.

## CALIBRATION OF CURRENT-MEASURING INSTRUMENTS DRIVES COMMERCIALIZATION OF NEW NIST TRANSCONDUCTANCE AMPLIFIER

A high-current, wideband transconductance amplifier has been developed by a NIST scientist that provides an unprecedented level of output current at high frequencies with exceptional stability, greatly exceeding the capabilities of any other known transconductance amplifier. The NIST amplifier has drawn intense interest

from a manufacturer of electronic instruments in response to needs by the Air Force for improved calibration of current-measuring instruments. Recently, one of the company's principals visited the NIST scientist to discuss the amplifier design and to observe it in operation. The Air Force Metrology Engineering Center in Ohio is using a commercially available transconductance amplifier for the calibration of current measuring devices, but the Air Force needs, and is developing a set of specifications for, improved transconductance amplifiers.

The NIST amplifier meets the anticipated specifications. It is capable of converting a signal of 5 V (root mean square, rms) applied to its input into a ground-referenced output current of 100 A (rms) over a frequency range from dc to 100 kHz, with a usable frequency extending up to 1 MHz. The amplifier has an output capability of 1000 W, a compliance voltage range of up to 10 V, and can deliver up to 400 A of peak-to-peak pulsed current. Functional tests have demonstrated the amplifier's low dc offset (5 mA at 100 A) and the fact that it is stable for loads of any practical inductance (i.e., it is not thrown into oscillations). The amplifier also offers generally low harmonic distortion and high output impedance.

## NIST-INDUSTRY COLLABORATION RESULTS IN FIRST REPORTED FABRICATION OF HIGH-TEMPERATURE SNS JOSEPHSON JUNCTIONS ON SILICON

A collaboration led by a NIST scientist and a scientist from private industry has successfully fabricated high-temperature superconducting (HTS) Josephson junctions on silicon wafers. This is the first report of superconductor-normal-superconductor (SNS) junctions on silicon, and the first report of any HTS junction on silicon that uses reactive-ion etching (RIE) to pattern the silicon. This achievement overcomes a serious barrier to the fabrication of such needed HTS devices as optically coupled infrared sensors and mixers, which require the low loss characteristic of a silicon substrate. Of potentially greater significance, it enables the fabrication of superconducting and semiconducting devices on the same substrate, opening new possibilities for the demanding area of miniaturized radiofrequency components for wireless communications.

The private company has pioneered techniques to grow high-quality films of  $\text{YBa}_2\text{Cu}_3\text{O}_7$  (YBCO) on silicon using epitaxial buffer layers; this expertise has been combined with the Josephson-junction capabilities at NIST. The fabrication process begins at NIST with the etching of a step into the silicon surface by means of a standard RIE process. The company then deposits

a thin film of YBCO on the wafer at an angle to the step, creating a break in the superconductor. A thin film of gold is deposited over the YBCO to bridge the gap in the superconductor, to form the SNS device. The final junction geometry is determined by ion milling. The resulting junctions, measured at NIST, have nearly ideal characteristics for applications requiring shunted Josephson junctions. The junctions respond to rf radiation in the predicted manner, with excellent response from a few GHz to 100 GHz at temperatures higher than 70 K.

### **NIST PROVIDES PWB INDUSTRY NEW METHOD FOR ELECTRICAL CHARACTERIZATION OF DIELECTRIC MATERIALS**

A method using time-domain reflectometry (TDR) has been devised by a NIST scientist for convenient measurements of the relative permittivity,  $\epsilon$ , of printed wiring board (PWB) dielectric materials. This work supports the PWB industry's need for a robust, inexpensive, accurate, and fast factory-floor measurement system for measuring  $\epsilon$  and the dielectric loss (given as  $\tan\delta$ ) of PWB dielectrics. Because product cost is of paramount importance to the PWB industry, sample preparation costs and time must be kept to a minimum. The TDR method uses a parallel-plate transmission line (PPTL) as the test specimen. Specimen preparation is straightforward and can be accomplished with routing equipment in the inventory of most PWB manufacturers; no photolithographic or chemical processing steps are required. The test instrument is a relatively inexpensive sampling oscilloscope and the specimen holder is a modified coaxial-to-microstrip adapter having no requirement for precise specimen location. The measurement process takes less than a minute.

A key aspect of the NIST work was the development of a simple model of the PPTL to describe its observed electrical behavior, subsequently verified with several transmission-line (TL) materials. The model describes the impedance of the actual PPTL specimen using a parallel combination of the impedance of three ideal TLs: an ideal PPTL, a parallel-line TL having an air dielectric, and a parallel-line TL having the PWB dielectric. An uncertainty analysis was performed that showed that the critical parameters for accurate  $\epsilon$  determinations are primarily dielectric and conductor thicknesses. The value of  $\epsilon$  thus obtained is an average value for the magnitude of the relative permittivity over the frequency range of approximately 100 MHz to 5 GHz. Because PWB designers use a scalar value for  $\epsilon$  in their design software, this average value is more applicable than a frequency-specific value. Comparing

measurements of using this method with the specifications of various manufacturers, and with corresponding values obtained by resonant cavity measurements, has shown agreement within about 2 % and repeatability better than 1 %.

### **ALGORITHM TESTING AND EVALUATION PROGRAM FOR COORDINATE MEASURING SYSTEMS**

A new NIST Special Test Service, the Algorithm Testing and Evaluation Program for Coordinate Measuring Systems (ATEP-CMS), has its first five industry customers. ATEP-CMS compares the customer's fit results to reference results of the NIST Algorithm Testing System's (ATS) internal algorithms. Customers receive a Report of Special Test, which summarizes the performance of their coordinate measuring system (CMS) software. With ISO 9000 certification becoming a common requirement among manufacturing inspection systems, ATEP-CMS offers U.S. industry a domestically available method of testing their CMS software. The ATEP-CMS Special Test Service goes beyond testing software since customers also may request the NIST ATS algorithms for their own use.

### **CUSTOM THERAPEUTIC FOOTWEAR ROUND TABLE MEETING**

The Custom Therapeutic Footwear Round Table Meeting, coordinated by the Footwear Industries of America and held in Washington, DC, included mainstream and therapeutic footwear industry leaders. NIST staff briefed the participants on the enterprise model that NIST is developing for custom therapeutic footwear manufacturing in the Systems Integration for Manufacturing Applications program. Participants discussed emerging technologies that correspond to the activities specified in that model for both custom and custom therapeutic footwear. They concluded that it would be beneficial to begin a collaborative effort to develop interoperability standards to integrate those manufacturing processes. A pilot project will be conducted to demonstrate the successful implementation and integration of the new manufacturing technologies.

### **SIXTH TOPICAL CONFERENCE ON QUANTITATIVE SURFACE ANALYSIS HELD**

The sixth topical conference on Quantitative Surface Analysis was held Oct. 16, 1995, as part of the annual National Symposium of the American Vacuum Society in Minneapolis. This conference consisted of five invited presentations followed by extended discussion

periods and 13 contributed papers. A feature of the conference was a demonstration of instrumental software and databases for different applications.

Recent efforts to measure Auger-electron spectra of solid elements with high-energy resolution and high accuracy were described by two invited speakers. Another invited speaker showed how the spectral shape of an x-ray photoelectron spectroscopy (XPS) peak and its associated inelastic tail could be analyzed to give information on the surface morphology and the depth distribution of the emitting atoms. The fourth invited speaker described data-analysis methods useful for applications of XPS and Auger-electron spectroscopy (AES). Methods for assessing the reliability of statistical analyses of surface analysis data, with particular emphasis on the estimation of parameters in XPS, were discussed by the fifth invited speaker. The contributed papers addressed different aspects of quantitative surface analysis by XPS, AES, secondary-ion mass spectrometry, sputtered-neutral mass spectrometry, and ion-scattering spectroscopy.

Like earlier conferences in the series, it provided an opportunity for more than 100 attendees to discuss recent advances in these areas of measurement research. As a forum for discussing current quantitative measurement problems, the conference also serves as one source of input to NIST's future research directions in programs for quantitative surface measurements.

#### **CENAM GUEST RESEARCHERS AT NIST ENHANCE INTERNATIONAL COLLABORATION**

Several scientists from the Centro Nacional de Metrología (CENAM) of Mexico are spending 6 months at NIST to gain expertise in various analytical disciplines that will benefit their own research programs upon return to their institute. They are guest researchers at NIST under arrangements made by the NIST Office of International and Academic Affairs and the participating divisions at NIST with full support from CENAM, the Mexican national metrology institution. One scientist from CENAM's Laboratory of the Metrology of Reference Materials is performing research with the microanalysis staff at NIST. The scientist is using state-of-the-art instrumentation in Fourier transform Raman and infrared microspectroscopy to participate in two projects with a NIST scientist. The first is the characterization of zirconia powders and coatings to obtain information on phase composition, a joint project with researchers in at NIST, leading to the certification of a reference material. The second is a collaboration with staff of the Paffenbarger Research Center of the American Dental Association Health Foundation at NIST involving the

study of biological mineralization, with a focus on cardiovascular calcification.

The guest researcher program with CENAM has other spinoffs that are leading to mutually beneficial scientific exchange, in part precipitated by the bi-national joint ventures evolving from the NAFTA agreements. Three members from the microanalysis staff at NIST were invited by CENAM to teach a short course on "X-Ray Microanalysis in Materials Science" in November 1995. A select group of scientists from Mexican industry attended the sessions, which provided them with the basics of accurate metrology and the latest advances in this analytical microprobe technique. These interactions are seen as aiding the transnational standardization of scientific practices and measurements essential for traceability in high-technology-based industries.

#### **IUPAC SETS STANDARDS FOR CHEMICAL DETECTION AND QUANTIFICATION LIMITS**

The International Union of Pure and Applied Chemistry (IUPAC) recently published recommendations for nomenclature and the evaluation of detection and quantification capabilities of chemical measurements. The document, prepared by a NIST scientist, meets long-standing needs for a sound, uniform basis for addressing the concepts underlying chemical detection and quantification, and for a common system of nomenclature among chemists for specifying these capabilities.

Currently, there are serious impediments to communication and understanding arising from the wide array of terminology and concepts used by chemists in different regions, adversely impacting issues in science, health and safety, and international trade. For example, the basic capability of a specific chemical measurement process to detect a given toxic contaminant in food might appear to vary over a wide range simply because of differing, and frequently unstated, "recipes" used for calculating a "detection limit." The IUPAC recommendations will remedy this situation.

A very important parallel development relates to the achievement of international consensus on detection concepts and terminology, not just for chemical measurements, but for metrology in general. Major progress toward this goal has occurred by concerted harmonization efforts between members of IUPAC and members of the International Organization for Standardization (ISO). An IUPAC-ISO harmonization meeting took place in Washington, DC, in July 1993, with a successful follow-up in late September 1995, in connection with the preparation of an ISO (TC69) Standard on the Capability of Detection.

## PACKING STRUCTURE OF ALKANETHIOL SELF-ASSEMBLED MONOLAYERS

Researchers at NIST are studying fundamental aspects of the structure and function of self-assembled monolayers (SAMs) attached to gold surfaces, which are promising materials for chemical and biological sensors, biomimetic devices, and fundamental studies of wetting and tribology. SAMs are functionalized alkanethiols, which bind to gold via a thiolate linkage; inter-chain dispersion forces compress the molecules into a dense monolayer film. The crystalline packing structure of the SAMs traditionally has been thought to be determined by inter-chain dispersion forces and gold-thiol interactions. In contrast, the physical and chemical properties of the exposed surface are determined principally by the end-group. This ability to customize surface properties by simply varying the end group is what makes SAMs so attractive. For example, by forming mixed composition monolayers of  $C_nCH_3$  and  $C_nOH$  one can tune the surface to be extremely hydrophobic or extremely hydrophilic.

Results of the NIST research now indicate that the end-group interactions have a much greater influence on crystalline packing structure than previously thought. Hydroxy-terminated SAMs were prepared by deposition of  $C_6OH$  vapor onto clean gold in an evacuated chamber and characterized in-situ using atomic-resolution scanning tunneling microscopy. The measured packing structure was fundamentally different than the hexagonal packing of the methyl-terminated SAMs. Further experiments revealed for the first time that the packing structure of hydroxy-terminated SAMs dynamically rearranges when they are hydrated using gas-phase transport of water vapor, also observed using STM. These results confirm the importance of end-group interactions in SAM packing. Understanding the roles of chemical and structural “forces” in the self-assembly process ultimately will lead to developing means for reliably producing the desired SAM arrays and the sensors based upon them.

## FUNDAMENTAL CONSTANTS ON THE WORLD WIDE WEB

The NIST World Wide Web server provides public access to a considerable amount of physical reference data over the Internet. The most popular database is the one that provides values of about 100 fundamental physical constants, such as the mass of the electron and the Avagadro constant. The database, which may be accessed at the URL <http://physics.nist.gov/funcon.html>, has been on-line for about a year. In this time there have been electronic requests for data from 17475 different

Internet addresses outside of NIST. This number is growing rapidly; for example, users at 3338 different addresses requested data in October alone. Most users download more than one page from the database, so the total number of pages retrieved is many times the number of Internet addresses from which requests come. It seems likely that the popularity of this database is not so much due to the curiosity of Internet surfers, but rather to the central importance of the constants in all of science and technology and the fact that NIST is viewed as an authoritative source for this information worldwide.

The database is taken from “The 1986 CODATA Recommended Values of the Fundamental Physical Constants,” Journal of Research of the National Bureau of Standards, Vol. 92, p. 85, 1987. While this is the latest set of CODATA (Committee on Data for Science and Technology) internationally recommended values, it is somewhat out of date; in many cases the uncertainties of the values are five or more times greater than the uncertainties that are currently possible. To bring the constants up to date, two scientists, in collaboration with a retired industrial scientist, are working on a new least-squares evaluation of the fundamental constants to provide up-to-date CODATA recommended values. The goal is to complete the adjustment by January 1997 and then to update the NIST fundamental physical constants WWW database.

The fundamental constants database is a product of NIST’s ECSED (Electronic Commerce in Scientific and Engineering Data) program.

## DYNAMICS OF HYDROGEN-BONDED INTERACTIONS EXPLORED

Time-resolved ultrafast infrared spectroscopy was used at NIST for the first time to study the dynamics, energetics, and cooperative bonding effects in hydrogen-bonded systems. Since hydrogen bonds are ubiquitous in nature—their interactions in biomolecules such as DNA and proteins govern structure, replication, and function—these investigations have advanced our limited understanding of such processes at the microscopic level.

For the first time, lifetime measurements were made of the complex OH and NH-stretch vibrations and it was observed that they monotonically decreased with decreasing OH and NH-stretch frequency (i.e., increased hydrogen-bond strength). In these experiments, pyrrole, methanol, and triethylsilanol were mixed with bases to form dilute, room temperature acid:base complexes. These results disagree with previous experiments on related systems.

Additional NIST experiments explored acid-base formation times of excited hydrogen-bond donors in equilibrium with bases. The vibrational lifetime of the "free" donors was found to decrease with increased base concentration. The bimolecular reaction rates which were deduced for these systems and the hydrogen-bond strength dependence on lifetime results suggest structurally specific factors critically affect hydrogen-bond formation and dissociation processes in biosystems.

### **NEW RADIOMETRIC FACILITY**

Infrared radiometry has an important role in space-based civilian, defense, and industrial applications. The growing realization among users of infrared radiometers of the critical role for calibration and characterization of these devices has led to the development of a new facility at NIST. This facility will be used to maintain an infrared scale for specialized applications not being served by current facilities at NIST. In particular, the capability for temperature and radiometric measurements on large-area, vacuum-operational, blackbody sources operated from 200 K to about 400 K will be established. One example of the type of scientific activity the NIST facility will support is the use of satellites for determining the temperature of the Earth's surface and atmosphere based on radiance measurements. These measurements serve as a basis for studies of global warming.

The first goal of the new facility will be to commission an infrared radiometer that will be used to intercompare large-area blackbody sources at such places as contractor's facilities in NASA's Mission To Planet Earth Project. This device is well under way and the prototype will be ready for testing late in FY 1996. The new facility is not limited to infrared measurements. The capability to make comparisons of large area visible sources also will be developed. For both infrared and visible sources, users will be able to bring their sources to NIST for calibration. This facility also will be used for hosting intercomparisons of field radiometers, user sources, and training of key personnel. A multipurpose classroom is available where short courses and workshops on radiometry will be held.

### **NIST ASSISTS MIT ON COMPUTERIZED TOMOGRAPHY SYSTEM FOR REAL-TIME MONITORING**

Physicists at NIST have been assisting the Massachusetts Institute of Technology (MIT) Manufacturing Institute in the design of an x-ray CT system to monitor the solidification front in continuous metal casting

processes for U.S. aluminum and steel manufacturers. In steel manufacturing alone, continuous casting accounts for more than 80 % of U.S. production. Precise tracking of the solidification front is expected to enable manufacturers to improve product uniformity for metal castings.

MIT staff have conducted feasibility experiments on the use of gamma radiation from cobalt-60 to perform radiography of a mixed metal solidification front in a test vessel. At NIST they have used high-energy x-ray beams from an electron accelerator to scale up to the megavolt energy region necessary to image the 15 cm process stream used in conventional metal casting. NIST scientists also are assisting with the design of the safety systems that will be required in the prototype pilot plant. The MIT Manufacturing Institute, with support from the National Science Foundation, has launched a consortium of industry and government laboratories to pursue development and construction of a prototype linac-based system.

### **UPGRADED TIME BROADCASTS FROM WWVB**

NIST has embarked on a major renovation and enhancement of the time broadcasts emanating from radio station WWVB located just north of Fort Collins, CO. These broadcasts are attractive for a number of applications because receivers and antennas can be particularly simple, small, and inexpensive, and because signal reception within buildings is feasible. However, the currently available signal strength has been marginal, particularly in areas along the U.S. east coast. One of the key objectives of this effort is to resolve this problem by increasing signal strength by at least 6 dB. This will provide U.S. industry options for new products serving both high-end timing applications and consumer needs.

A key roadblock to this project has been the very high cost of new transmitters. This difficulty was overcome when the Navy agreed to provide NIST with three surplus high-power transmitters they had in storage. Purchased new, these transmitters would have cost NIST more than \$1 million. Installation of the transmitters requires substantial engineering modifications at the site. These include new transmission lines to antennas, new impedance matching networks, and modified interfacing to the transmitters. The current plan is to complete installation and modifications in about a year.

### **DIRECT OBSERVATION OF FERROELECTRIC DOMAIN PATTERNS IN PERIODICALLY POLED LITHIUM NIOBATE SINGLE CRYSTALS**

Quasi-phase-matching through periodic poling in single crystal materials such as lithium niobate is a promising

approach to the generation of wavelengths of light not available from conventional lasers. However, the production of regular, reproducible ferroelectric domain patterns necessary for practical application of this technique has proven difficult for the short period ( $\sim 1 \mu\text{m}$ ) patterns necessary for many applications. Recent synchrotron x-ray diffraction imaging experiments at NIST performed on samples of periodically poled lithium niobate have revealed that crystal lattice defects may be one source of the difficulty. These defects, the nature of which is currently unknown, appear to be correlated with irregularities in the ferroelectric domain pattern induced by the periodic poling. Further examination of these defects and their interactions with domains is expected to lead to improvement of this important electro-optic material and optimization of the periodic poling process.

### **NIST BALANCING ENVIRONMENTAL AND ECONOMIC PERFORMANCE OF MATERIALS**

NIST is collaborating with the U.S. Environmental Protection Agency to develop and automate by 1997 a decision support system to identify building materials that improve environmental performance with little or no increase in cost. The joint project is known as BEES, an acronym for Building for Environmental and Economic Sustainability. NIST is developing, automating, and standardizing the methodology. EPA is developing a publicly available database of environmental performance data, to which NIST will add economic performance data. The BEES software will access the database of environmental and economic performance data. BEES will measure the environmental performance of a material using a multidisciplinary tool known as life-cycle assessment. It is based on the belief that all stages in the life of a material generate environmental impacts and must be analyzed. The stages include raw material extraction and processing, material manufacture, installation, operation and maintenance, and recycling and waste management. Economic performance will be measured using the life-cycle cost method, which includes the costs over a given study period of initial investment, replacement, operation, maintenance and repair, and disposal. BEES will assist designers and manufacturers in comparing the environmental and economic performance of alternative building materials.

### **NIST PUBLISHES COMPUTER SECURITY HANDBOOK**

NIST Special Publication 800-12, An Introduction to Computer Security: The NIST Handbook, provides a

broad overview of computer security to help readers understand their computer security needs and develop a sound approach to the selection of appropriate security controls. It offers assistance in securing computer-based resources such as hardware, software, and information by explaining important concepts, cost considerations, and the interrelationships of security controls. The handbook is useful for those who have computer security responsibilities in both the public and private sectors.

### **ATM NETWORK SIMULATOR DEVELOPED**

NISTIR 5703, The NIST ATM Network Simulator, Operation and Programming, Version 1.0, describes an asynchronous transfer mode (ATM) network simulator that has been developed to provide a means for researchers and network planners to analyze the behavior of ATM networks without the expense of building a real network. The simulator is a tool that gives the user an interactive modeling environment with a graphical user interface. This tool allows the user to create different network topologies, control component parameters, measure network activity, and log data from simulation runs.

### **INFORMATION RETRIEVAL SOFTWARE AVAILABLE**

NIST's written natural language processing group is making available a public domain package of source code and documentation (Z39.50/PRISE 1.0), which includes a basic Z39.50 UNIX client/server pair integrated with the prototype indexing and search engines (PRISE) developed by NIST. The server is designed to isolate the search engine from the details of the Z39.50 protocol and to minimize the effort needed to interface the server to natural language search engines other than PRISE.

The NIST PRISE system treats documents and queries as lists of words and responds to a query with a list of documents ranked in order of their statistical similarity to the query.

The goals of the current work with Z39.50 are to promote the availability of information retrieval services by publishing source code for a working Z39.50 client/server—a set of building blocks to give commercial, academic, and government information retrieval developers a head start, and to provide an enhanced, user-friendly version of a PRISE application within a Z39.50 interface. NIST Special Publication 500-229, Z39.50 Implementation Experiences, presents a collection of papers on successful Z39.50 implementations.

---

## Standard Reference Materials

---

**"AT THE ASTERISK, THE TIME WILL BE..."**

NIST recently upgraded the equipment that provides its Automated Computer Time Service, or ACTS, for setting clocks in computers. Computers (and other equipment) can be programmed to call (303) 494-4774 to receive a signal that contains the time of day. The service now has 12 incoming lines (in rotary), and now PC-based servers can accept calls at speeds up to 9600 baud. These changes should provide smoother service to a broader variety of user modems. ACTS receives more than 9000 calls a day on average but can handle more than 28000 at peak usage. Software to use ACTS is available for \$45 by ordering Standard Reference Material 8101b from the NIST SRM Program, (301) 975-6776, fax: (301) 948-3730, e-mail: [srminfo@enh.nist.gov](mailto:srminfo@enh.nist.gov). NIST also provides a similar service via various servers on the Internet and receives over 50000 "hits" a day, a number that doubles every 2 months or so. (ftp to "time.nist.gov" to obtain the free downloadable software and documentation; log in as "ANONYMOUS" and use your Internet address as the password. Change directory to "/pub/daytime" and read the file "readme.daytime." The ACTS software is also available free at this site: change directory to "/pub/acts" and read the file "readme.acts"). World Wide Web surfers can see a printout of the exact time at <http://time.nist.gov:13/>, but this will not reset your computer's clock. And what about that "asterisk" in the title? The NIST computer systems use an asterisk as the on-time marker, analogous to the tone transmitted in NIST's familiar time signals heard world-wide on short-wave radio and on the telephone at (303) 499-7111.

### MAJOR REVISION OF THE COATING THICKNESS STANDARD REFERENCE MATERIALS 1357 THROUGH 1364A

The first revision of the Coating Thickness Standards SRMs 1357 through 1364a is nearing completion and is expected to reach customers before October 1996 and the remaining stock of previous standards is consumed. These standards, developed in the 1960s, consist of preconfigured sets of coupons of fine grained copper of thicknesses ranging from 2.5  $\mu\text{m}$  to 2 mm, which has been electrodeposited onto low carbon steel substrates. The uniform coatings are then overplated with a thin protective layer of chromium and the coupon's total coating thickness is certified. They are primarily intended for use in calibrating coating thickness measurement instruments based on the magnetic induction

principle and are used by the organic and inorganic coating industry for the nondestructive measurement of non-magnetic coatings over magnetic substrates. Advances in the precision of the instruments employed in the laboratory and in the field, coupled with the present policy for reporting uncertainties associated with measurements executed at NIST, required the re-evaluation of the production and certification of such standards. The effects of thickness, composition, surface roughness, and mechanical working of the substrate material on the uncertainties associated with the thickness measurement have been determined during the material selection for the production of these standards. Stricter control over the cell geometry and electrode configuration during the electrodeposition stages now yields uniform plates with less than 1 % deviation from the targeted thickness values. In addition, during the certification stage, reproducibility of the positioning of the probe and the distance of the measurement spot from the edges has been increased to minimize edge effects. Uncertainties associated with human operations, calibration curves, probe resolutions, and measurement modes have been modified by increasing the substrate thickness and the size of the measurement area without compromising the uncertainties listed. This allows greater leeway during the selection of the measurement spot by the user. An attempt has been made to tailor the thickness distribution offered within the preconfigured sets by surveying users with respect to the thickness ranges of their present applications and the uncertainties associated with their measurement protocol.

---

## Standard Reference Data

---

### HIGH-TEMP SUPERCONDUCTOR DATABASE RELEASED

The NIST High-Temperature Superconductors Database for personal computers provides materials researchers in industry, federal laboratories, and universities with rapid access to carefully evaluated information on 24 thermal, mechanical and superconducting properties for oxide superconductors. Standard Reference Database 62 covers approximately 130 series of compounds derived from the yttrium-barium-copper-oxygen (Y-Ba-Cu-O), bismuth-strontium-calcium-copper-oxygen (Bi-Sr-Ca-Cu-O), thallium-strontium-calcium-copper-oxygen (Tl-Sr-Ca-Cu-O), and lanthanum-copper-oxygen (La-Cu-O) chemical families, along with numerous other variants of the cuprate (copper-contain-

ing) and bismate materials that are known to have superconducting phases. Materials are described by specification, while characterization information includes processing details and chemical conditions. The data are from approximately 400 papers published in the years 1987-1993. SRD 62, PC Version 1.0, is available for \$265 from the Standard Reference Data Program, Rm. 113, Building 820, NIST, Gaithersburg, MD 20899-0001, (301) 975-2208, fax: (301) 926-0416, e-mail: [srdata@enh.nist.gov](mailto:srdata@enh.nist.gov).

**CRYSTALLIZATION DATA NOW ON THE WWW**

In order to determine the structure of large complex protein molecules, scientists form protein crystals and bombard them with x rays. The resulting diffraction patterns help scientists determine molecular structure. However, finding the right conditions for forming protein crystals can be a long and tedious process. The NIST/NASA/CARB Biological Macromolecule Crystallization Database—now available on the Internet's World Wide Web—helps speed the process by offering data on crystallization conditions, macromolecules, crystals and crystallization references (CARB is the Center for Advanced Research in Biotechnology). The database recently was redesigned for Internet access at <http://ibm4.carb.nist.gov:4400/carb.html>. The searchable on-line database includes 2353 crystal entries from 1557 biological macromolecules for which diffraction quality crystals have been obtained. These include proteins, nucleic acids, and viruses. The database also contains the NASA Protein Crystal Growth Archive, which includes crystallization data from NASA-supported space experiments. Scientists also can purchase the database from NIST for \$340. For purchasing information, contact the Standard Reference Data Program, Rm. 113, Building 820, NIST, Gaithersburg, MD 20899-0001, (301) 975-2208, fax: (301) 926-0416, e-mail: [srdata@enh.nist.gov](mailto:srdata@enh.nist.gov).

# AT \$28.00 A YEAR, CAN YOU AFFORD NOT TO KNOW WHAT'S GOING ON AT THE NATION'S MEASUREMENT SCIENCE LABORATORY?



The *Journal of Research* Brings You  
Up-to-Date Scientific Articles and  
Information on:

- Measurement Science and Technology
- Calibration Services
- Standard Reference Materials
- Cooperative Research Opportunities and Grants
- Conference Reports

AND MUCH MORE!

It's All At Your Fingertips In the *Journal of Research of the NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY*

## SUBSCRIBE TODAY !

***Journal of  
Research of the  
National  
Institute of  
Standards and  
Technology***

Order Processing Code

**6596**

**1. Please Type or Print**

(Company or personal name)

(Additional address/attention line)

(Street address)

(City, State, ZIP Code)

(      )

(Daytime phone including area code)

May we make your name/address available to other mailers?

YES  NO

**Superintendent of Documents Subscription Order Form**

YES, send me     subscriptions  
to the **JOURNAL OF RESEARCH OF THE  
NATIONAL INSTITUTE OF STANDARDS  
AND TECHNOLOGY** at \$28 per subscrip-  
tion (6 times a year) so I can stay up to date  
on the latest developments in measurement  
science and technology.

**2. The total cost of my order is \$        . All prices include  
domestic postage and handling. International customers please  
add 25 percent.**

**3. Please Choose Method of Payment:**

Check payable to the Superintendent of Documents

GPO Deposit Account

VISA, or MasterCard

*Thank you for your order!*

(Credit Card Expiration Date)

(Purchase Order No.)

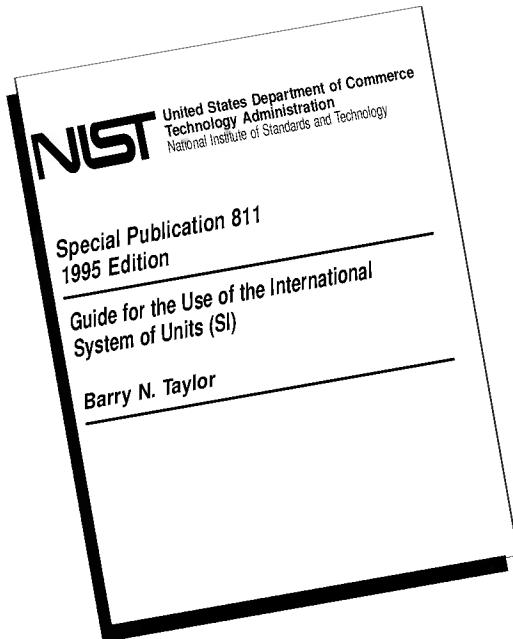
(Signature)

(10-95)

**4. MAIL TO:** New Orders, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954.

# The International System of Units (SI)

## *The Modern Metric System*



Uncertain about the International System of Units (universally abbreviated SI), the modern metric system used throughout the world? Do you need to know the proper way to express the results of measurements and the values of quantities in units of the SI? Do you need to know the NIST policy on the use of the SI? Then you need the 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*.

The 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*, by Barry N. Taylor, is now available.

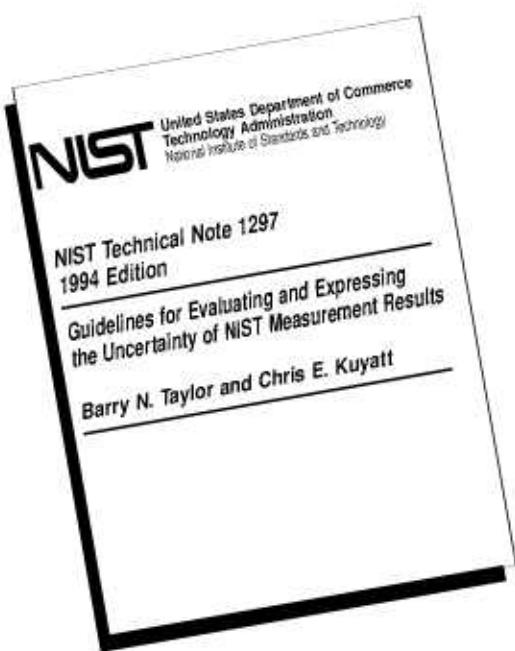
The 1995 edition of SP 811 corrects a number of misprints in the 1991 edition, incorporates a significant amount of additional material intended to answer frequently asked questions concerning the SI and SI usage, and updates the bibliography. The added material includes a check list for reviewing the consistency of written documents with the SI. Some changes in format have also been made in an attempt to improve the ease of use of SP 811.

The topics covered by SP 811 include:

- NIST policy on the use of the SI in NIST publications.
- Classes of SI units, those SI derived units that have special names and symbols, and the SI prefixes that are used to form decimal multiples and submultiples of SI units.
- Those units outside the SI that may be used with the SI and those that may not.
- Rules and style conventions for printing and using quantity symbols, unit symbols, and prefix symbols, and for spelling unit names.
- Rules and style conventions for expressing the results of measurements and the values of quantities.
- Definitions of the SI base units.
- Conversion factors for converting values of quantities expressed in units that are mainly unacceptable for use with the SI to values expressed mainly in units of the SI.
- Rounding numbers and rounding converted numerical values of quantities.

Single copies of the 84-page SP 811 may be obtained from the NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001, telephone: 301-975-2002, fax: 301-948-3825.

# Evaluating and Expressing the Uncertainty of Measurement Results



Uncertain about expressing measurement uncertainty? Do you need to know how NIST states the uncertainty of its measurement results and how you can implement their internationally accepted method in your own laboratory? Then you need the newly available 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*.

The 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, by Barry N. Taylor and Chris E. Kuyatt is now available.

The 1994 edition of TN 1297 includes a new appendix—Appendix D—which clarifies and gives additional guidance on a number of topics related to measurement uncertainty, including the use of certain terms such as accuracy and precision. Very minor word changes have also been made in a few portions of the text of the 1993 edition in order to recognize the official publication in October 1993 by the International Organization for Standardization (ISO) of the *Guide to the Expression of Uncertainty in Measurement* on which TN 1297 is based. However, the NIST policy on measurement uncertainty, Statements of Uncertainty Associated with Measurement Results, which is reproduced as Appendix C of TN 1297, is unchanged.

It is expected that the 1994 edition of TN 1297 will be even more useful than its immediate predecessor, the 1993 edition, of which 10 000 copies were distributed worldwide.

Those United States readers who wish to delve into the subject of measurement uncertainty in greater depth may purchase a copy of the 100-page ISO *Guide* from the Sales Department of the American National Standards Institute (ANSI), 105-111 South State Street, Hackensack, NJ 07601. Copies may also be purchased from the ISO Central Secretariat, 1 rue de Varembé, Case postale 56, CH-1211 Genève 20, Switzerland.

Single copies of the 20-page TN 1297 may be obtained from the NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001, telephone: 301-975-2002, fax: 301-948-3825.

# NIST *Technical Publications*

## *Periodical*

---

**Journal of Research of the National Institute of Standards and Technology**—Reports NIST research and development in those disciplines of the physical and engineering sciences in which the Institute is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Institute's technical and scientific programs. Issued six times a year.

## *Nonperiodicals*

---

**Monographs**—Major contributions to the technical literature on various subjects related to the Institute's scientific and technical activities.

**Handbooks**—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

**Special Publications**—Include proceedings of conferences sponsored by NIST, NIST annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

**National Standard Reference Data Series**—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NIST under the authority of the National Standard Data Act (Public Law 90-396). NOTE: The Journal of Physical and Chemical Reference Data (JPCRD) is published bimonthly for NIST by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements are available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

**Building Science Series**—Disseminates technical information developed at the Institute on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

**Technical Notes**—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NIST under the sponsorship of other government agencies.

**Voluntary Product Standards**—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NIST administers this program in support of the efforts of private-sector standardizing organizations.

*Order the following NIST publications—FIPS and NISTIRs—from the National Technical Information Service, Springfield, VA 22161.*

**Federal Information Processing Standards Publications (FIPS PUB)**—Publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NIST pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

**NIST Interagency Reports (NISTIR)**—A special series of interim or final reports on work performed by NIST for outside sponsors (both government and nongovernment). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche form.

**U.S. Department of Commerce**

National Institute of Standards and Technology  
Gaithersburg, MD 20899-0001

Official Business  
Penalty for Private Use \$300

Special Fourth Class Rate—Book